

FINAL
REMEDIAL INVESTIGATION AND
FEASIBILITY STUDY (RI/FS) FOR THE
LANDSBURG MINE SITE

Prepared by:

Golder Associates Inc. (GAI)
with assistance from SubTerra, Inc.

on behalf of:

The Landsburg PLP Steering Committee

for:

The Washington State Department of Ecology

February 1, 1996

923-1000.147
0105rh11.CH0

EXECUTIVE SUMMARY

This report, prepared by Golder Associates Inc. (Golder) for the Landsburg Mine Potentially Liable Parties Group (PLP Group), presents the results of the Remedial Investigation (RI) and Feasibility Study (FS) for the Landsburg Mine site. The Landsburg Mine site is a State of Washington Priority Listed site under the auspices of the Model Toxics Control Act (MTCA), Chapter 70.105D RCW. Pursuant to the Washington State Department of Ecology's authority under MTCA, Ecology issued Agreed Order No. DE 983TC-N273 (WDOE 1993a) on July 21, 1993, which directed the Landsburg PLP Group to conduct this RI/FS. This RI/FS report has been prepared in accordance with the Agreed Order, the *Landsburg Phase I Remedial Investigation/Feasibility Study (RI/FS) Work Plan* (Golder 1992a), and the requirements of WAC 173-340-350 State Remedial Investigation and Feasibility Study. This RI/FS will be used to support final remedy selection as documented in the Cleanup Action Plan (CAP) for the site.

REMEDIAL INVESTIGATION

The Landsburg Mine site is a former underground coal mine located approximately 1.5 miles northwest of Ravensdale in southeast King County, Washington. The Cedar River passes within approximately 500 feet of the site to the north. The mine site occupies property owned by Palmer Coking Coal Company (PCC) and Plum Creek Timber Company, L.P. PCC operated an underground coal mine known as the Landsburg Mine from the late 1940s until approximately 1975. The Rogers Seam was mined from 1959 until 1975. The mined section of the Rogers coal Seam has a near vertical dip and consists of coal and interbedded shale approximately 16 feet wide. The mined section is about a mile in length. Mining occurred at depths of up to 750 feet using a mining method locally called "booming" which followed the coal seam vertically. As a result of underground mining of the Rogers Seam, a subsidence trench developed on the land surface above the mine workings. The dimensions of the trench vary, from about 60 to 100 feet wide, between 20 to 60 feet deep, and about 3/4 mile long.

Based on currently available information, this trench was used in the late 1960s to the late 1970s for disposal of various industrial waste materials, construction materials, and land-clearing debris. Drums, liquid from tanker trucks and other industrial materials were disposed of in the northern portion of the trench. Disposal of land clearing debris continued until the early 1980s. Currently, the site is secured by a fence and locked gate which encloses the northern portion of the trench where disposal occurred.

Several preliminary environmental investigations have been performed at the site (Geraghty and Miller 1990; Applied Geotechnology 1990; Washington State Department of Health 1992). During these preliminary investigations, hazardous substances were not detected in area private and public supply wells, mine portal groundwater discharges or soil gases.

Due to continued concerns over potential environmental hazards posed by the Mine, however, Ecology commissioned a Site Hazard Assessment (SHA) study in 1991 (Ecology and Environment 1991). Ecology then requested potentially liable parties (PLPs) to perform an expedited response action (ERA) which resulted in the removal of over 100 exposed 55-gallon drums from the trench (Landsburg PLP Steering Committee 1991). These investigations found

hazardous substances, including volatile and semi-volatile organic compounds, PCBs, cyanide and metals, in drum contents, adjacent soils and ponded surface water within the northern portion of the trench where prior waste disposal occurred.

On the basis of these results, Ecology and the PLP Group entered into an Agreed Order (WDOE 1993a) which directed the PLP Group to conduct an RI/FS to evaluate the need for remedial action. The scope of work for the RI was outlined in the *Landsburg Phase I Remedial Investigation/Feasibility Study (RI/FS) Work Plan* (Golder 1992a) which was incorporated by reference into the Agreed Order. The approach taken during the RI was to focus environmental sampling efforts on potential pathways of chemicals leaving the mine and not on wastes present within the mine itself. Investigation of wastes in the mine was limited due to physical constraints and dangers, and difficulties associated with taking samples in the mine. Data collection activities conducted under the RI included the following primary tasks:

- **Air Monitoring.** A series of air surveys was conducted down the centerline of the trench to monitor for the presence of organic vapors which could be associated with waste disposal.
- **Source Characterization in Rogers Trench (Geophysical Investigation).** A magnetometer survey was conducted along the centerline of the Rogers Seam trench to identify areas of potential buried waste.
- **Private Well Survey.** A well survey was conducted to identify private and public wells within the Study Area, and to support the selection (in consultation with the State Department's of Health and Ecology) of wells for quarterly sampling.
- **Monitoring Well Drilling and Installation.** Seven new monitoring wells (LMW-1 through -7) were installed at the site. Wells LMW-2/4 and LMW-3/5 consisted of nested well pairs installed within the coal at each end of the trench at the points of expected mine groundwater discharge. LMW-1 was installed overtop a suspected location of a fault and tunnel connecting offset portions of the Rogers Seam. Wells LMW-6 and -7 were installed in adjacent coal seams (Frasier and Landsburg Seams) to provide indications of water quality typical of adjacent coal seams. Angled drilling methods were used at the LMW-4 and LMW-7 well locations to intercept the vertical coal seam.
- **Quarterly monitoring of surface water and groundwater.** Surface water associated with Rogers Mine portals #2 and #3, and groundwater from the seven site wells and from 14 selected area private wells were sampled for chemical analysis over four rounds of quarterly sampling. The samples were submitted for a broad range of chemical analyses including metals and cyanide, volatile and semi-volatile organics, pesticides and PCBs, and general chemical parameters.
- **Surface Soil Sampling.** Surface soils around the trench rim perimeter and downslope of portal #3 were sampled for chemical analysis.

- **Topographic Survey and Geodetic Control.** Using aerial photogrammetry techniques, a topographic base map of the site was prepared to 2 ft contours. Horizontal control was established based on the Washington State Plane Coordinate System as required under MTCA.

On the basis of the RI data, the following primary conclusions were reached:

Nature and Extent of Chemicals in the Environment. Chemicals associated with the prior waste disposal activities at the site do not appear to be exiting the mine (Section 5.4). Extensive sampling of air, soil, groundwater and surface water at the site have indicated that chemicals associated with the waste are limited only to soils located within that portion of the trench known to have been used for prior waste disposal; levels of chemicals throughout the remainder of the Study Area are consistent with typical background conditions.

Source Characteristics. Geophysical data, the results of sampling and historical information indicate that any potential remaining wastes in the trench appear to be confined to the northern half of the trench in the areas utilized for waste disposal (Section 3.2). The nature of these potential remaining waste materials is uncertain beyond that which is known regarding what was disposed in the trench. Wastes remaining could include some intact and partially intact drums buried beneath the trench bottom surface at some depth. However, based on the condition of the drums observed in the ERA, the duration of burial, physical damage known to occur during placement, etc., the vast majority of the drums have probably already ruptured or deteriorated in some manner.

Potential Future Pathways of Chemicals Exiting the Mine. As part of the RI, it was necessary to evaluate the *potential* pathways for chemical migration from the mine. The groundwater pathway represents the most significant potential pathway (Section 3.6.4). Waste present in the trench is believed to be confined to the northern half of the site. Groundwater flow beneath this portion of the site is to the north through the mined out and highly permeable Rogers Seam. Flow laterally away from the mine is negligible due to the tightness of faults and the vertical orientation and layering of low-permeability strata. The primary pathway of chemicals potentially exiting the mine is through the Rogers seam to the north. Future groundwater monitoring activities should focus on the detection of potential releases from the north end of the mine. The chance that such a discharge could occur at the southern end is unlikely given the direction of groundwater flow and the absence of waste in this portion of the mine.

Once exiting the site, any potential chemical constituents leaving the northern portion of the mine would flow primarily to the north and northeast towards the Cedar River, consistent with the local ground surface topography (Figure 3-24). This flow would occur within the Rogers coal Seam and within the glacial outwash materials which overlie the coal. No drinking water wells are currently located along this primary pathway of groundwater flow. The two monitoring wells (LMW-2 and -4) located along this pathway did not show any evidence of contamination during the RI.

While the primary flow direction is towards the river, it is also possible that some flow could occur to the northwest within the glacial outwash deposits located to the north of the mine. If groundwater were to flow in this direction, potential receptor points would include the wells located to the northwest of portal #2 along the Summit-Landsburg Road. Well PW-4 is the closest well and is approximately 1,500 ft away from the trench. It is not considered likely, however, that groundwater flow would occur to these wells given the strong topographic gradient towards the river.

At the southern end of the mine, potential receptors include the cluster of wells along the Kent-Kangley Road just southwest of portal #3, and the Clark Springs facility. The Clark Springs facility is approximately 2,500 ft from the portal. It is not likely that these wells would ever be impacted, however, as discharge of chemicals from the mine's southern end is a remote possibility.

Applicable or Relevant and Appropriate Requirements (ARARs). The primary potential ARARs for the site include the following (Chapter 4):

- Model Toxics Control Act (MTCA) RCW 70.105D and MTCA Cleanup Regulations WAC 173-340; and
- Minimum Functional Standards for Solid Waste Handling WAC 174-304.

In addition, portions of the dangerous waste regulations (WAC 173-303) may be relevant and appropriate.

Adequacy of RI Data. The data collected under this Remedial Investigation are considered adequate to characterize site conditions and to support evaluation and selection of a preferred remedial alternative in the FS. This document, therefore, represents a complete and final RI and FS set of documents that will be sufficient to enable Ecology to make decisions regarding the final Cleanup Action Plan (CAP) for the site.

FEASIBILITY STUDY

The Feasibility Study (FS) for the Landsburg Mine site consists of the following elements:

- **Development of remedial action objectives.** Objectives and cleanup levels are established that provide the basis for developing and evaluating alternatives for remediation of the site.
- **Identification and screening of remediation technologies.** Candidate technologies are screened to obtain a list of feasible technologies for use in assembling remediation alternatives.
- **Identification and screening of remediation alternatives.** Remediation technologies are assembled into a wide range of alternatives for remedial action at the site. The

alternatives are then screened to obtain a focused list of alternatives for further consideration.

- **Development and evaluation of remediation alternatives.** Alternatives remaining after screening are further developed and subjected to detailed evaluation. Consideration of the evaluation results in a preferred alternative for the site.

Remedial Action Objectives

Remedial action objectives (RAOs) are site-specific goals based on acceptable exposure levels that are protective of human health and the environment and consider applicable or relevant and appropriate requirements (ARARs). Remedial action objectives identify risk pathways that remedial actions should address, and identify acceptable exposure levels for residual constituents of concern. The remedial action objectives for this site are:

- Minimize the potential for future direct exposure of human or ecological receptors to any waste constituents that may remain at the site.
- Reduce the potential for migration of any waste constituents from the trench in groundwater, surface water or airborne dust.

Identification and Screening of Remediation Technologies

Potentially applicable remediation technologies have been identified for each of the general response actions. Technologies have been considered for each of the following categories:

- Institutional controls (including monitoring)
- Containment
- Removal
- Ex-Situ Treatment (including reuse and recycling)
- In-Situ Treatment
- Disposal

The technologies have been screened based on effectiveness, implementability, and cost to obtain a set of technologies that could be applied at the Landsburg Mine site.

Identification of Remediation Alternatives

Remediation technologies retained following the screening process are then assembled into remediation alternatives. The technologies are combined to create a wide range of alternatives that represent various approaches to achieving remedial action objectives. Remediation alternatives are developed to meet the following MTCA requirements:

- Protect human health and the environment,
- Comply with cleanup standards,

- Comply with applicable laws and regulations,
- Provide for compliance monitoring,
- Use permanent solutions to the maximum extent practicable, and
- Provide for a reasonable restoration time frame.

Consideration of public concerns is performed by Ecology after the FS is completed and is based on public comments on the draft Cleanup Action Plan (CAP). Public concerns may result in modifications to the remedial action proposed in the draft CAP. Any modifications would be incorporated into the final CAP.

The following alternatives were developed for remediation of the Landsburg Mine site:

Alternative 1: No Action. A "no action" alternative is included as a baseline for comparison to the other alternatives. This alternative would leave the site in its current state, assuming no restrictions on future site use and no site maintenance or monitoring.

Alternative 2: Institutional Controls and Monitoring. Institutional controls include deed restrictions, fencing and warning signs, and groundwater use restrictions, as well as periodic site inspections and maintenance of the physical components of the controls. Groundwater use restrictions would be employed to prevent exposure to site groundwater. Thus, if site groundwater were to become affected by waste constituents, there would be no immediate exposure. Exposure could occur only following off-site migration. Routine, periodic monitoring would detect constituents of concern in groundwater were it to become affected.

Alternative 3: Trench Backfill. This alternative would protect human health and the environment by providing long-term containment of any waste and affected soil in the trench. This alternative would consist of filling the trench in the area where waste disposal occurred, combined with grading to provide proper stormwater drainage and prevent stormwater collection in the trench area. Institutional controls and periodic maintenance and monitoring would also be included.

Alternative 4: Soil Cap. This alternative would protect human health and the environment by providing reliable long-term containment of any waste and affected soil in the trench. As with Alternative 3, the trench would be filled only in the area where waste disposal occurred, combined with grading to provide proper stormwater drainage and prevent stormwater collection in the trench area. The backfill would be covered by a soil cap to provide additional protection, and add a thicker vegetated soil layer for improved evapotranspiration and erosion control. Institutional controls and periodic maintenance and monitoring would also be provided.

Alternative 5: Low-Permeability Soil Cap. This alternative is very similar to Alternative 4, except that a low-permeability liner, constructed by compacting suitable soil, would be included in the cap design to decrease the amount of infiltration through the cap, thus decreasing the potential for affecting groundwater. Institutional controls and periodic maintenance and monitoring would also be provided.

Alternative 6: FML Cap. This alternative is very similar to Alternative 5, except that the low-permeability liner would be constructed using a synthetic flexible membrane liner (FML) instead of compacted soil. Institutional controls and periodic maintenance and monitoring would also be provided.

Alternative 7: FML/GCL Cap. This alternative is very similar to Alternative 6, except that a geosynthetic clay liner (GCL) would be added to provide two low-permeability liners instead of one. Two liners do not provide lower infiltration than a single liner, but provide additional reliability for long-term protection. Institutional controls and periodic maintenance and monitoring would also be provided.

Alternative 8: Excavation and Off-Site Disposal of Surficial Affected Soil and Capping. This alternative would consist of removal of surficial soil in the trench containing concentrations of constituents of concern above remediation goals followed by off-site disposal. The trench would then be backfilled and graded for proper stormwater drainage. Because waste and affected soil would presumably remain buried in the trench, a cap meeting minimum functional standards under WAC 173-304 would be placed over the trench. Institutional controls and periodic maintenance and monitoring would also be provided.

Alternative 9: Excavation and Off-Site Disposal of All Waste and Affected Soil. In this alternative, all waste and affected soil would be removed from the trench for off-site disposal. Appropriate disposal facilities would be used, depending on the waste designation (hazardous, dangerous, or non-hazardous). Institutional controls, maintenance, and monitoring would not be necessary for this alternative because all waste and affected soil would be removed from the site.

Screening of Alternatives

The remediation alternatives summarized above were evaluated based on effectiveness, implementability, and cost. Based on the screening evaluation (Section 7.3.3), the following alternatives were retained for detailed development and evaluation:

- Alternative 1: No Action
- Alternative 2: Institutional Controls and Monitoring
- Alternative 4: Soil Cap
- Alternative 5: Low-Permeability Soil Cap
- Alternative 6: FML Cap
- Alternative 7: FML/GCL Composite Cap
- Alternative 9: Excavation and Off-Site Disposal of All Waste and Affected Soil.

Threshold Requirements

Under MTCA, remediation alternatives must meet the following threshold requirements (WAC 173-340-360(2)):

- Protection of human health and the environment
- Compliance with cleanup standards

- Compliance with ARARs
- Provision for compliance monitoring

For reasons discussed in Section 9.1, the following alternatives do not meet one or more of the MTCA threshold criteria for selection as the preferred alternative:

Alternative 1 (No Action)

Alternative 2 (Institutional Controls and Monitoring)

Alternative 4 (Soil Cap).

These alternatives are retained for the full evaluation, however, because their inclusion provides perspective on the benefits and costs of the alternatives, much as the “no action” alternative provides a baseline for comparison. It is minimal additional effort to include the alternatives in the full evaluation, and excluding them would not change the evaluation scoring or preferred alternative.

The remaining alternatives 5, 6, 7 and 9 meet the minimum requirements of the MTCA threshold criteria.

Use of Permanent Solutions and Comparative Evaluation of Alternatives

WAC 173-340-360(3) specifies that the remediation alternatives must use permanent solutions to the maximum extent practicable. WAC 173-340-360(5) specifies that “Ecology recognizes that permanent solutions [defined at WAC 173-340-360(5)(b)] may not be practicable for all sites. A determination that a cleanup action satisfies the requirement to use permanent solutions to the maximum extent practicable is based on consideration of a number of factors.” The specified factors, or criteria, are:

- Overall protectiveness
- Long-term effectiveness and reliability
- Short-term effectiveness
- Reduction in toxicity, mobility, and volume
- Implementability
- Cost
- Community acceptance

These criteria are described in Section 9.2. Selection of a remediation alternative is based on comparative evaluation of the alternatives (that satisfy the threshold criteria) using 5 permanence criteria: 1) long-term effectiveness and reliability, 2) short-term effectiveness, 3) reduction in toxicity, mobility, and volume, 4) implementability, and 5) cost. Overall protectiveness and community concerns are not included in the comparative evaluation for reasons discussed in Section 9.2.

Each alternative is scored relative to the other alternatives for the four non-cost permanence criteria. Because of the nature of the criteria and the uncertainties in the evaluation, the scores for these four criteria are expressions of relative qualitative or semi-quantitative professional

judgments. A scale of 0 (worst) to 10 (best) is used. The evaluation scores are shown in Table ES-1 and discussed in Section 9.4.

The relative values of the non-cost criteria are then determined. The relative criteria values are expressions of what a scoring unit of one criterion is worth compared to a scoring unit of another criterion. The assigned relative values are converted to criteria weightings, i.e., percentage of the overall score. The scores for the four non-cost criteria are combined using the criteria weightings to give overall alternative scores. These scores express the net benefit of the alternatives. The net benefit, or overall non-cost scores, are given in Table ES-1. Using these scores, the preference ranking of the alternatives before consideration of cost is as follows (most to least preferred):

1. Alternative 5 (Low-Permeability Soil Cap)
2. Alternative 6 (FML Cap)
3. Alternative 7 (FML/GCL Cap)
4. Alternative 4 (Soil Cap)
5. Alternative 2 (Institutional Controls and Monitoring)
6. Alternative 1 (No Action)
7. Alternative 9 (Excavation and Disposal).

It should not be surprising that Alternative 9 (Excavation and Disposal) has an overall score less than Alternative 1 (No Action). This ranking reflects the many problems associated with excavation and the uncertain benefit (i.e., lack of reliability). Alternative 9 (Excavation and Disposal) would be much more likely than Alternative 1 (No Action) to cause actual harm to humans in the form of construction accidents for site workers and traffic accidents in the community. It would also be much more likely to cause exposure to waste constituents, meaning greater risk to both human and ecological receptors. These known risks must be balanced against the potential risks of no action.

After the non-cost evaluation, a comparison of the cost and benefit of the alternatives is made. Under WAC 173-340-360(5)(d)(vi), “a cleanup action shall not be considered practicable if the incremental cost of the cleanup action is substantial and disproportionate to the incremental degree of protection it would achieve over a lower preference cleanup action.” Thus, the alternative with the highest ratio of incremental benefit to incremental cost is the preferred alternative. As show in Table ES-1, Alternative 5 (Low-Permeability Soil Cap) provides the best incremental cost-effectiveness of the alternatives.

Conclusion

Alternative 5 (Low-Permeability Soil Cap) provides the best incremental cost-effectiveness, in addition to providing the best net benefit. Alternative 5 meets all threshold criteria (protection of human health and the environment, compliance with cleanup standards, compliance with ARARs, and provision for compliance monitoring). It provides the optimum combination of long-term effectiveness and reliability, short-term effectiveness, implementability, and reduction of toxicity, mobility, and volume. In addition, this alternative provides good cost-effectiveness. Considering the criteria and approach specified in WAC 173-340-360(5), Alternative 5 is the

remediation alternative for the Landsburg Mine site that is “permanent to the maximum extent practicable”, and is therefore the preferred alternative.

TABLE ES-1

ACRONYMS

| | |
|---------|---|
| ARAR | applicable or relevant and appropriate requirement |
| ARI | Analytical Resources Inc. |
| BGS | below ground surface |
| CAP | Cleanup Action Plan |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act of 1980 |
| CFR | Code of Federal Regulations |
| CLP | Contract Laboratory Program |
| COC | contaminants of concern |
| COPC | contaminants of potential concern |
| CQA | construction quality assurance |
| DNR | Washington State Department of Natural Resources |
| DNS | Determination of Nonsignificance |
| DQO | Data Quality Objective |
| EA | Environmental Assessment |
| Ecology | Washington State Department of Ecology |
| EDR | Environmental Data Resources |
| EIS | Environmental Impact Statement |
| EMI | electromagnetic inductance |
| EPA | United States Environmental Protection Agency |
| ERA | Expedited Response Action |
| FID | flame ionization detector |
| FML | flexible membrane liner |
| FS | feasibility study |
| GCL | geosynthetic clay liner |
| gpm | gallons per minute |
| GPR | ground penetrating radar |
| HQ | hazard quotient |
| KCC | King County Code |
| LICR | lifetime incremental cancer risk |
| LMW | Landsburg Monitoring Well |
| MCL | Maximum Contaminant Level |
| MCLG | Maximum Contaminant Level Goal |
| MFS | Minimum Functional Standards |
| MSL | mean sea level |
| MTCA | Model Toxics Control Act |
| NCP | National Oil and Hazardous Substances Contingency Plan |
| NEPA | National Environmental Policy Act |
| NGVD | national geodetic vertical datum |
| NPL | National Priorities List |
| OSHA | Occupational Safety and Health Administration |
| OSM | Office of Surface Mining |
| OVA | organic vapor analyzer |

ACRONYMS (Cont.)

| | |
|----------|--|
| OVM | organic vapor monitor |
| PAH | polynuclear aromatic hydrocarbon |
| PCB | polychlorinated biphenyls |
| PCC | Palmer Coking Coal Company |
| PDF | probability distribution function |
| PHS/HRTG | Priority Habitat and Species and Natural Wildlife Heritage Data Maps |
| PID | photo-ionization detector |
| PLP | Potentially Liable Party |
| PLPSC | Potentially Liable Party Steering Committee |
| POTW | publicly-owned treatment works |
| PQL | practical quantification limit |
| PSAPCA | Puget Sound Air Pollution Control Authority |
| QA | quality assurance |
| QAPP | Quality Assurance Project Plan |
| QC | Quality Control |
| RAO | remedial action objective |
| RCRA | Resource Conservation and Recovery Act |
| RCW | Revised Code of the State of Washington |
| RI | remedial investigation |
| SARA | Superfund Amendments and Reauthorization Act |
| SDWA | Safe Drinking Water Act |
| SDG | Sample Delivery Group |
| SEPA | State Environmental Policy Act |
| SHA | Site Hazard Assessment |
| SIDS | Sample Integrity Data Sheets |
| SMCL | Secondary Maximum Contaminant Level |
| SVOA | semi-volatile organics analysis |
| TAL | target analyte list |
| TBC | To Be Considered |
| TCE | trichloroethene |
| TCL | target compound list |
| TCLP | Toxicity Characteristic Leaching Procedure |
| TDS | total dissolved solids |
| TPH | total petroleum hydrocarbon |
| TSCA | Toxic Substances Control Act |
| USGS | United States Geological Survey |
| UCL | upper confidence limit |
| UTL | upper tolerance limit |
| VOA | volatile organic analysis |
| VOC | volatile organic compound |
| WAC | Washington Administrative Code |
| WDOE | Washington State Department of Ecology |
| WDOH | Washington State Department of Health |
| WDW | Washington State Department of Wildlife |

TABLE OF CONTENTS

| | <u>Page No.</u> |
|---|-----------------|
| EXECUTIVE SUMMARY | |
| ACRONYMS | |
| | |
| 1. INTRODUCTION | 1-1 |
| 1.1 Purpose and Rationale | 1-1 |
| 1.2 Background | 1-1 |
| 1.3 Overview of the RI/FS Process | 1-3 |
| 1.4 Report Organization | 1-4 |
| | |
| 2. RI/FS DATA COLLECTION ACTIVITIES | 2-1 |
| 2.1 Task 3 - Air Monitoring | 2-1 |
| 2.2 Task 4 - Facility Environmental Assessment | 2-2 |
| 2.2.1 Title History Report | 2-3 |
| 2.2.2 Interviews | 2-3 |
| 2.2.3 Review of Available Ground Water Quality Data | 2-3 |
| 2.2.4 Review of Government Records | 2-4 |
| 2.2.5 Aerial Photograph Review | 2-4 |
| 2.2.6 Site Reconnaissance | 2-4 |
| 2.3 Task 5 - Private Well Survey | 2-5 |
| 2.3.1 Well Inventory, Inspection and Verification | 2-5 |
| 2.3.2 Selection of Private Wells Included in Groundwater Sampling Program | 2-6 |
| 2.4 Task 6 - Surface Water Sampling and Flow Monitoring from Portals #2 and #3 | 2-6 |
| 2.4.1 Flow Monitoring | 2-7 |
| 2.4.2 Surface Water Sampling | 2-7 |
| 2.5 Task 7 - Surface Soil Sampling | 2-8 |
| 2.5.1 Trench Rim Perimeter Soils | 2-9 |
| 2.5.2 Portal Soils | 2-10 |
| 2.6 Task 8 - Geophysical Investigation | 2-10 |
| 2.6.1 Source Characterization in Rogers Trench | 2-10 |
| 2.6.2 Geophysical Surveys at Monitoring Well Locations | 2-12 |
| 2.7 Task 9 - Monitoring Well Drilling and Installation | 2-17 |
| 2.7.1 Determination of Well Locations | 2-17 |
| 2.7.2 Drilling and Well Installation | 2-18 |
| 2.7.3 Inclinator Surveys | 2-22 |
| 2.7.4 Hydraulic Testing | 2-22 |
| 2.7.4.1 Slug Testing | 2-23 |
| 2.7.4.2 Pump Testing | 2-25 |
| 2.7.5 Installation of Dedicated Sampling Pumps | 2-25 |

TABLE OF CONTENTS (Cont.)

| | <u>Page No.</u> |
|---|-----------------|
| 2.8 Task 10 - Groundwater Sampling and Analysis | 2-25 |
| 2.8.1 Private Well Groundwater Sampling | 2-25 |
| 2.8.2 Monitoring Well Groundwater Sampling | 2-27 |
| 2.9 Task 11 - Topographic Survey and Geodetic Control | 2-29 |
| 2.10 Task 12 - Ecological and Social Data | 2-29 |
| 2.10.1 Meteorology | 2-30 |
| 2.10.2 Surface Water Flow Data (Cedar River) | 2-30 |
| 2.10.3 Land Use | 2-30 |
| 2.10.4 Endangered Species | 2-31 |
| 2.10.5 Priority Habitat and Species | 2-31 |
| 2.11 Task 13 - Geologic Reconnaissance | 2-31 |
| 2.11.1 Site Walk Over and Geologic Mapping | 2-31 |
| 2.11.2 Activity 13b - Backhoe Trenching Perpendicular to Rogers Seam for Geologic Definition | 2-32 |
| 3. SITE PHYSICAL DESCRIPTION | 3-1 |
| 3.1 Site Location And Topography | 3-1 |
| 3.2 Source Characteristics | 3-2 |
| 3.2.1 Site Mining and Waste Disposal Activities | 3-2 |
| 3.2.2 Previous Investigations | 3-4 |
| 3.2.2.1 Site Hazard Assessment | 3-5 |
| 3.2.2.2 Expedited Response Action | 3-6 |
| 3.2.3 Results of the Rogers Trench Geophysical Survey | 3-8 |
| 3.3 Geological Characteristics | 3-10 |
| 3.3.1 Regional Geology | 3-10 |
| 3.3.1.1 Stratigraphy | 3-11 |
| 3.3.1.2 Structure | 3-13 |
| 3.3.2 Site Geology | 3-14 |
| 3.3.2.1 Stratigraphy | 3-14 |
| 3.3.2.2 Structure | 3-15 |
| 3.4 Site Mining Related Characteristics | 3-16 |
| 3.4.1 Mining History | 3-17 |
| 3.4.1.1 General Description | 3-18 |
| 3.4.1.2 Coal Seam Characteristics | 3-18 |
| 3.4.1.3 Mining Method | 3-19 |
| 3.4.1.4 Mine Layout and Sequencing | 3-20 |
| 3.4.1.5 Coal Production and Extraction Ratio | 3-21 |
| 3.4.1.6 Water Inflow and Pumping Data | 3-21 |
| 3.4.2 Remnant Condition of the Rogers Seam, Underground Workings and Surface Site | 3-23 |
| 3.4.2.1 Trench Bottom Stability | 3-23 |
| 3.4.2.2 Trench Sidewall Stability | 3-24 |

3.4.2.3 Potential for Waste Movement After Dumping

3-24

TABLE OF CONTENTS (Cont.)

| | <u>Page No.</u> |
|--|-----------------|
| 3.5 Surface Water and Meteorologic Characteristics | 3-24 |
| 3.5.1 Surface Water | 3-24 |
| 3.5.1.1 Cedar River | 3-25 |
| 3.5.1.2 Rock Creek | 3-25 |
| 3.5.1.3 Site Drainage Features | 3-26 |
| 3.5.2 Meteorological Characteristics | 3-27 |
| 3.5.2.1 Regional Characteristics | 3-27 |
| 3.5.2.2 Site Characteristics | 3-27 |
| 3.6 Groundwater Characteristics | 3-28 |
| 3.6.1 Regional Hydrogeology | 3-28 |
| 3.6.2 Study Area General Conditions | 3-29 |
| 3.6.3 Mine Site Groundwater Conditions | 3-30 |
| 3.6.3.1 Groundwater Occurrence | 3-30 |
| 3.6.3.2 Groundwater Flow Directions | 3-33 |
| 3.6.3.3 Hydraulic Properties | 3-34 |
| 3.6.3.4 Geochemistry | 3-37 |
| 3.6.4 Conceptual Model of Site Groundwater Flow | 3-38 |
| 3.6.4.1 Groundwater Flow | 3-38 |
| 3.6.4.2 Primary Potential Pathways and Receptors | 3-39 |
| 3.7 Social And Ecological Characteristics | 3-40 |
| 3.7.1 Land Use | 3-40 |
| 3.7.2 Water Use | 3-41 |
| 3.7.2.1 Surface Water | 3-41 |
| 3.7.2.2 Groundwater | 3-41 |
| 3.7.3 Ecology | 3-42 |
| 3.7.3.1 Endangered Species | 3-42 |
| 3.7.3.2 Priority Habitats and Species | 3-43 |
| 3.7.3.3 Sensitive Areas | 3-44 |
| 4. POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS | 4-1 |
| 4.1 Introduction/Overview | 4-1 |
| 4.2 ARARs Based on Federal Laws | 4-1 |
| 4.3 ARARs Based on State Laws | 4-2 |
| 5. NATURE AND EXTENT OF CHEMICAL CONSTITUENTS EXCEEDING REGULATORY CRITERIA | 5-1 |
| 5.1 Approach | 5-1 |
| 5.2 Data Screening | 5-2 |
| 5.2.1 Media Addressed | 5-2 |
| 5.2.2 Data Validation | 5-3 |

TABLE OF CONTENTS (Cont.)

| | <u>Page No.</u> |
|--|-----------------|
| 5.2.3 Comparison to Potential ARARs (Screening) | 5-4 |
| 5.2.3.1 Groundwater | 5-5 |
| 5.2.3.2 Surface Water | 5-6 |
| 5.2.3.3 Soil | 5-6 |
| 5.2.4 Consideration of Other Criteria | 5-7 |
| 5.2.4.1 Field and Trip Blank Data | 5-7 |
| 5.2.4.2 Consistency of Detection | 5-8 |
| 5.2.4.3 Background Data | 5-9 |
| 5.2.4.4 Lists of COPC | 5-10 |
| 5.3 Extent Of Contaminants of Potential Concern (COPC) | 5-11 |
| 5.3.1 Air | 5-11 |
| 5.3.2 Groundwater | 5-12 |
| 5.3.2.1 Distribution of COPC | 5-12 |
| 5.3.2.2 Water Quality Typical of Coal-Mine Drainage | 5-14 |
| 5.3.3 Surface Water | 5-15 |
| 5.3.4 Soil | 5-16 |
| 5.4 Conclusions and Identification of COCs | 5-16 |
| 6. RI SUMMARY | 6-1 |
| 6.1 Site Background | 6-1 |
| 6.2 RI Data Collection Activities | 6-2 |
| 6.3 Site Physical Conditions | 6-4 |
| 6.3.1 General | 6-4 |
| 6.3.2 Source Characteristics | 6-4 |
| 6.3.3 Geology | 6-5 |
| 6.3.4 Mine History and Condition | 6-6 |
| 6.3.4.1 History | 6-6 |
| 6.3.4.2 Mining Methods | 6-7 |
| 6.3.4.3 Mine Stability | 6-7 |
| 6.3.5 Meteorology and Surface Water | 6-8 |
| 6.3.5.1 Surface Water | 6-8 |
| 6.3.5.2 Meteorological Characteristics | 6-8 |
| 6.3.6 Hydrogeology | 6-9 |
| 6.3.7 Ecologic and Social Characteristics | 6-10 |
| 6.3.7.1 Land Use (Zoning) | 6-10 |
| 6.3.7.2 Water Use | 6-10 |
| 6.3.7.3 Endangered Species | 6-10 |
| 6.3.7.4 Priority Habitats and Species | 6-10 |
| 6.3.7.5 Sensitive Areas | 6-11 |
| 6.4 ARARs | 6-12 |
| 6.5 Nature And Extent Of Chemical Constituents | 6-14 |

| | |
|--|------|
| 6.6 <u>Conceptual Model</u> of Waste Fate and Migration | 6-15 |
| 6.6.1 <u>Prior</u> Materials Discharged to Trench | 6-15 |
| 6.6.2 Current Condition | 6-17 |
| 7. REMEDIAL ACTION OBJECTIVES AND ASSEMBLY OF REMEDIATION ALTERNATIVES | 7-1 |
| 7.1 Development Of Remedial Action Objectives | 7-1 |
| 7.1.1 Remedial Action Objectives | 7-1 |
| 7.1.2 Preliminary Remediation Goals | 7-2 |
| 7.2 Identification And Screening Of Technologies | 7-3 |
| 7.2.1 General Response Actions | 7-4 |
| 7.2.2 Institutional Controls And Monitoring | 7-4 |
| 7.2.3 Containment | 7-5 |
| 7.2.3.1 Trench Backfill | 7-6 |
| 7.2.3.2 Capping | 7-6 |
| 7.2.3.3 Dust Control | 7-9 |
| 7.2.3.4 Surface Water Controls | 7-9 |
| 7.2.3.5 Vertical Barriers | 7-9 |
| 7.2.3.6 Horizontal Barriers | 7-11 |
| 7.2.3.7 Hydraulic Groundwater Containment | 7-11 |
| 7.2.4 Removal | 7-12 |
| 7.2.4.1 Excavation | 7-12 |
| 7.2.4.2 Groundwater Extraction | 7-13 |
| 7.2.5 Ex-Situ Treatment | 7-13 |
| 7.2.5.1 Waste and Affected Soil | 7-13 |
| 7.2.5.2 Groundwater | 7-16 |
| 7.2.6 In-Situ Treatment | 7-16 |
| 7.2.7 Disposal | 7-17 |
| 7.3 Assembly And Screening Of Remediation Alternatives | 7-18 |
| 7.3.1 Assembly Of Alternatives | 7-18 |
| 7.3.2 Description Of Alternatives | 7-19 |
| 7.3.3 Screening Of Alternatives | 7-23 |
| 7.3.4 Summary Of Retained Alternatives | 7-24 |
| 8. DEVELOPMENT OF ALTERNATIVES | 8-1 |
| 8.1 Common Elements | 8-1 |
| 8.1.1 Institutional Controls | 8-1 |
| 8.1.2 Monitoring | 8-2 |
| 8.1.2.1 Short-Term Monitoring | 8-2 |
| 8.1.2.2 Long-Term Monitoring | 8-3 |
| 8.1.3 Trench Backfill | 8-5 |
| 8.1.4 Grading and Surface Water Management | 8-6 |
| 8.1.5 Capping | 8-7 |
| 8.2 <u>Description Of</u> Remediation Alternatives | 8-7 |
| 8.2.1 <u>Alternative 1: No Action</u> | 8-7 |

| | |
|---|------|
| 8.2.2 Alternative 2: Institutional Controls and Monitoring | 8-8 |
| 8.2.3 Alternative 4: Soil Cap | 8-8 |
| 8.2.4 Alternative 5: Low-Permeability Soil Cap | 8-8 |
| 8.2.5 Alternative 6: FML Cap | 8-9 |
| 8.2.6 Alternative 7: FML/GCL Cap | 8-10 |
| 8.2.7 Alternative 9: Excavation and Disposal | 8-11 |
| 9. EVALUATION OF ALTERNATIVES | 9-1 |
| 9.1 Threshold Evaluation | 9-1 |
| 9.1.1 Protection of Human Health and the Environment | 9-1 |
| 9.1.2 Compliance with Cleanup Standards | 9-2 |
| 9.1.3 Compliance with ARARs | 9-2 |
| 9.1.4 Provision for Compliance Monitoring | 9-2 |
| 9.1.5 Summary of Threshold Evaluation | 9-3 |
| 9.2 Use of Permanent Solutions | 9-3 |
| 9.2.1 Overall Protectiveness | 9-3 |
| 9.2.2 Long-Term Effectiveness and Reliability | 9-4 |
| 9.2.3 Short-Term Effectiveness | 9-5 |
| 9.2.4 Reduction of Toxicity, Mobility, and Volume | 9-5 |
| 9.2.5 Implementability | 9-6 |
| 9.2.6 Cost | 9-6 |
| 9.2.7 Community Acceptance | 9-6 |
| 9.3 Comparative Evaluation Methodology | 9-7 |
| 9.4 Evaluation of Remediation Alternatives for Permanence | 9-8 |
| 9.4.1 Long-Term Effectiveness and Reliability | 9-8 |
| 9.4.1.1 Effectiveness | 9-9 |
| 9.4.1.2 Reliability | 9-9 |
| 9.4.1.3 Overall Score for the Long-Term Effectiveness and Reliability Criterion | 9-10 |
| 9.4.2 Short-Term Effectiveness | 9-10 |
| 9.4.3 Reduction in Toxicity, Mobility and Volume | 9-11 |
| 9.4.4 Implementability | 9-11 |
| 9.4.5 Net Benefit (Overall Non-Cost Evaluation) | 9-12 |
| 9.4.6 Cost | 9-12 |
| 9.4.7 Cost: Benefit Analysis and Overall Evaluation | 9-13 |
| 9.4.8 Uncertainty Analysis | 9-14 |
| 10. REFERENCES | 10-1 |

LIST OF TABLES

| | |
|------|---|
| ES-1 | Summary of Remediation Alternative Evaluation |
| 2-1 | Results of Private Well Survey |
| 2-2 | Groundwater and Surface Water Sampling Summary |
| 2-3 | Soil Sampling Summary |
| 2-4 | Monitoring Well Construction Summary |
| 3-1 | Coal Analysis Report Summaries - Rogers Seam |
| 3-2 | Rogers Seam - Mine Maps |
| 3-3 | Sequence of Mining in the First Level |
| 3-4 | Sequence of Mining in the Second Level |
| 3-5 | Sequence of Mining in the Third and Fourth Levels |
| 3-6 | Landsburg Mine - Rogers Seam Mined/Washed Coal Tonnages |
| 3-7 | Daily Average Stream Flow Data for the Cedar River |
| 3-8 | Precipitation and Snowfall Data at Landsburg for 1931-1993 |
| 3-9 | Temperature Data at Landsburg for 1931-1993 |
| 3-10 | Results of Slug Test Analyses |
| 4-1 | Identification of Potential Federal ARARs for the Landsburg Mine Site |
| 4-2 | Identification of Potential State and Local ARARs for the Landsburg Mine Site |
| 4-3 | Potential ARAR Values for Groundwater |
| 4-4 | Potential ARAR Values for Surface Water |
| 4-5 | Potential ARAR Values for Soil |
| 5-1 | Data Validation Summary |
| 5-2 | Compounds Detected in Field and Trip Blanks |
| 5-3 | Analytes Detected in Groundwater Samples from Landsburg Monitoring Wells |
| 5-4 | Analytes Detected in Groundwater Samples from Landsburg Private Wells |
| 5-5 | Analytes Detected in Surface Water Samples from Portal #2 and Portal #3 |
| 5-6 | Analytes Detected in Landsburg Rim Soil Samples |
| 5-7 | Analytes Detected in Portal Soil Samples |
| 5-8 | Analytes Detected in Backhoe Trench Soil Samples |
| 5-9 | Summary of Historical Soil Chemical Data Collected from within Trench |
| 5-10 | Preliminary List of Compounds Exceeding Potential ARARs for Groundwater |
| 5-11 | Preliminary List of Compounds Exceeding Potential ARARs for Surface Water |
| 5-12 | Preliminary List of Compounds Exceeding Potential ARARs for Soil |
| 5-13 | State-Wide Soil Background Values for Metals Exceeding Regulatory Criteria |
| 5-14 | Air Monitoring Data from the First Trench Walk-Through |
| 5-15 | Air Monitoring Data from the Second Trench Walk-Through |
| 5-16 | Air Monitoring Data from the Third Trench Walk-Through |
| 5-17 | Field Groundwater Turbidity Measurements |
| 5-18 | Water-Quality Typical of Coal-Mine Drainage in the State of Washington Compared to Landsburg Mine Water Quality |

LIST OF TABLES (Cont.)

- 7-1 Summary of Technology and Process Option Screening
- 7-2 Summary of Trench Remediation Alternatives and Screening

- 9-1 Estimated Infiltration for Different Cap Designs
- 9-2 Summary of Remediation Alternative Evaluation
- 9-3 Summary of Stochastic Uncertainty Analysis

LIST OF FIGURES

- 1-1 Site Location
- 1-2 Landsburg Study Area
- 1-3 Street Map of the Study Area Vicinity
- 1-4 PCC and Plum Creek Timber Property Boundaries

- 2-1 Air Monitoring Locations
- 2-2 Private Well Locations
- 2-3 Monitoring Well and Portal Locations
- 2-4 Portal 3 Flow Station
- 2-5 Trench Rim, Portal 2 and Backhoe Test Pit Soil Sampling Locations
- 2-6 Portal 3 Soil Sampling Locations
- 2-7 Approximate Locations of Geophysical Surveys
- 2-8 Locations of Geophysical Survey Lines in Vicinity of LMW-1
- 2-9 Locations of Geophysical Survey Lines North of LMW-2 and LMW-4 by Cedar River
- 2-10 Locations of Geophysical Survey Lines in Vicinity of LMW-3 and LMW-5
- 2-11 Locations of Geophysical Survey Lines in Vicinity of LMW-6
- 2-12 Locations of Geophysical Survey Lines in Vicinity of LMW-7
- 2-13 Decontamination Area
- 2-14 Groundwater Disposal Location at North End of Trench
- 2-15 Groundwater Disposal Location at South End of Trench
- 2-16 Aerial Photo of Site

- 3-1 Site Features and Topography
- 3-2 Landsburg Mine Plan
- 3-3 Profile Along Landsburg Mine Trace
- 3-4 Sampling Locations for Site Hazard Assessment
- 3-5 Drum Removal Conducted During ERA
- 3-6 Results of Geophysical Survey along Rogers Trench
- 3-7 Surficial Geology of the Study Area Vicinity
- 3-8 Map View for Landsburg Cross-Sections
- 3-9 Cross-Section A-A' Along Strike at Coal Seam
- 3-10 Cross-Section B-B'
- 3-11 Cross-Section C-C'

LIST OF FIGURES (Cont.)

- 3-12 Cross-Section D-D'
- 3-13 Section through Rogers Seam Illustrating Layout of "Booming" Round
- 3-14 Landsburg Mine Bedrock Structure
- 3-15 Approximate Volume Along Remnant Trench
- 3-16 Major Study Area Surface Water Features
- 3-17 Detail Plan of Surface Water Bodies within Trench
- 3-18 Conceptual Groundwater Flow in Glacial Drift Deposits
- 3-19 Piezometric Surface Contours of the Primary Groundwater System
- 3-20 First Round Groundwater Data Trilinear Plot
- 3-21 Second Round Groundwater Data Trilinear Plot
- 3-22 Third Round Groundwater Data Trilinear Plot
- 3-23 Fourth Round Groundwater Data Trilinear Plot
- 3-24 Primary Pathway of Potential Contaminant Flow
- 3-25 Study Area Zoning
- 3-26 Potential Wetlands, Sensitive Areas and Priority Habitats within the Study Area

- 5-1 Quarterly Sampling Results for COPC at Landsburg Monitoring Wells
- 5-2 Quarterly Sampling Results for COPC at Landsburg Private Wells
- 5-3 Turbidity vs Measured Al, Fe and Mn

- 7-1 Cap Designs

- 8-1 Trench Areas
- 8-2 Capped Area and Drainage Ditches
- 8-3 Current Topography and Stormwater Drainage

- 9-1 Cost vs. Benefit for All Alternatives
- 9-2 Cost vs. Benefit for Cap Alternatives

LIST OF APPENDICES

- APPENDIX A Level 1 Environmental Assessment
- APPENDIX B Private Well Logs and General Hydrologic Data
- APPENDIX C Analytical Data
- APPENDIX D Core Photos
- APPENDIX E Borehole and Well Construction Logs and Backhoe Trench Logs
- APPENDIX F Well Testing Data and Analysis
- APPENDIX G HELP Model Output
- APPENDIX H Cost Estimates
- APPENDIX I Probabilistic Uncertainty Analysis
- APPENDIX J Geotechnical Soil Data
- APPENDIX K Geophysical Data